EN200

LAB #8

MATERIALS AND MATERIALS TESTING LAB

Instructions

1. This lab is **conducted in R57** on the lab deck of Rickover Hall.

2. You will need to **bring this lab to the lab period**. You must have completed the calculations in part 1, 1 to 16 on pages 2 to 8 before the lab. You will not have time to cover these in the lab itself.

3. The lab is to be performed and submitted individually. You can ask questions and discuss the content of the lab, but the **submitted work must be your own**.

4. **All work must be shown on your lab for proper credit.** This means that you must show generalized equations, substitution of numbers, units and final answers. Engineering is communication. Other people should be able to understand your work.

5. **This lab is to be submitted at the end of the lab period**.

6. There should be sufficient work to last the entire 1 hour and 50 minutes of this lab. If you do finish early then check your work. If you get less than 100% you have done yourself an injustice by finishing early.

Student Information

Name: _____

Section: _____

Date: _____

Aim:

- Reinforce the students' understanding of material properties.
- Demonstrate how material properties can be determined from experimental data.
- Demonstrate the differences between the properties of 1018 and 1090 steel and Al 2024.
- Demonstrate and show the applications of various Non-Destructive Testing techniques.

Part 1: Initial Work

Apparatus:

1. The apparatus for this experiment consists of several sets of equipment used to test material properties. They can be split into 2 sets.

    a. Destructive Testing Equipment.

    - Instron 4206 Tensile Force Machine
    - Tinius Olsen Impact Testing Machine
    - SATEC Systems Fatigue Tester

    b. Non-Destructive Testing Equipment.

    - Wilson Instruments Rockwell Hardness Machine
    - Ultrasonic Testing Equipment
    - Eddy Current Tester
    - Magnetic Flux Tester
    - Visual Testing and Dye Penetrant Testing Equipment.

    Additionally, the results of radiographic testing on various welds will be shown.

Material Strength

2. You will recall that the strength of a material is defined as:

> *"...a measure of a materials ability to resist deformation and maintain its shape."*

This is quantified in terms of yield stress (σ_y) or ultimate tensile stress (UTS). In the box below, sketch a stress/strain diagram for a material showing these 2 quantities.

3. The plots at enclosure 1, 2 and 3 show the output from the Instron Machine for the materials 1018 steel, 1090 steel and 2024 aluminum respectfully. The machine takes a standard sample of material and stretches it until failure; this will be shown during the lab.

4. You will notice that the output consists of a plot of Force (lb) against elongation (in). These values can then be converted to stress and strain values.

   a. In the box below give the equation that links the force, F (lb) to the stress, σ (psi) it is creating in a material.

   b. Give the equation that links elongation, e (in) to the strain, ε (in/in) it is creating in a material.

5. The standard sample used in the Instron machine is drawn at Figure 1. It consists of a cylinder exactly 2 inches long with a cylindrical diameter of 0.26 inches.

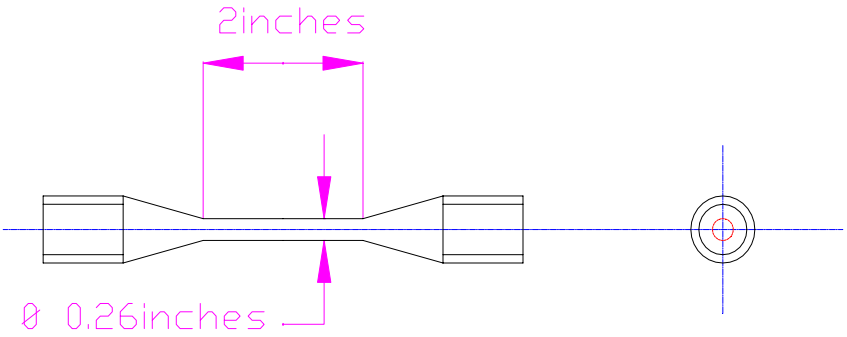

Figure 1 – The Standard Material Sample

6. Use this information, the force/elongation plots at the enclosures and equation 4a above to complete the following.

Cross Sectional Area of Sample =

Material	**1018 Steel**	**1090 Steel**	**2024 Aluminum**
Force at which material yields (lb)			
Yield Stress, σ_y (psi)			
Maximum force (lb)			
Ultimate Tensile Stress, UTS (psi)			

7. From this data.

Which material has the highest strength? _____

Which material has the lowest strength? _____

Ductility

8. You will recall that ductility is defined as follows:

".....a measure of a materials ability to deform before failure."

It can be quantified by reading the value of strain at the fracture point (ε_f) or by calculating the reduction of cross sectional area at fracture as a percentage of the original cross sectional area.

To enable the last calculation to be performed the diameters of the standard sample after fracture need to be known. They are as follows:

1018 Steel	-	0.161 inches
1090 Steel	-	0.240 inches
2024 Aluminum	-	0.218 inches

9. Using this information, the enclosures and equation 4b, complete the following:

Material	**1018 Steel**	**1090 Steel**	**2024 Aluminum**
Elongation at Fracture (in)			
Strain at Fracture (in/in)			
Final X-Sectional Area, A_f (in^2)			
Loss in X-Section Area, A_l (in^2)			
% Reduction in X-Sec Area			

10. From this data.

Which material is the most ductile? _____

Which material is the least ductile? _____

Toughness

11. You will recall that toughness is defined as;

".....a measure of a materials ability to absorb energy."

In fact there are 2 measurements of toughness.

a. Material toughness can be found from the force/elongation diagrams like those at the enclosure. How is it calculated?_____

_____

What are the units of toughness when measured in this way?_____

b. Toughness can also be measured from a Charpy v-notch test. This is a test that measures the energy absorbed by a material when fractured by a sudden impact. Figure 2 shows a typical apparatus set-up for the test.

The impact toughness is determined from finding the difference in potential energy before and after the hammer has fractured the material. In the box give the equation for calculating potential energy.

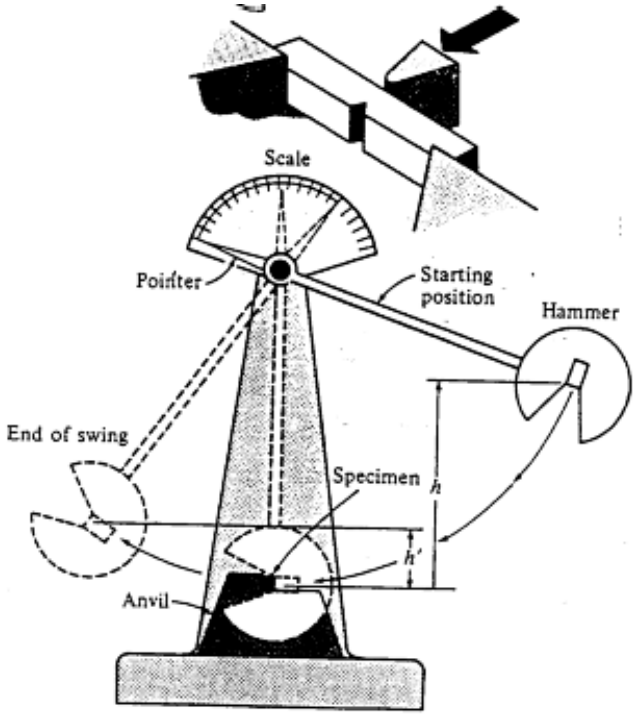

Figure 2 – Charpy v-notch test apparatus

The Charpy v-notch test will be demonstrated in the lab.

12. Using the following information complete the table below. Beware of your units.

- Weight of hammer = 55 lb
- Initial height of hammer = 57.625 inches

Material	**Initial Potential E (ft-lb)**	**Final Height of Hammer (in)**	**Final Potential E (ft-lb)**	**Impact Toughness (ft-lb)**
1018 Steel		33.000		
1090 Steel		55.625		
2024 Aluminum		46.125		

13. From this data.

Which material has the highest impact toughness at room temperature?_____

Which material has the lowest impact toughness at room temperature? _____

14. Of the 2 measures of toughness.

a. Which measurement would be most relevant to a submarine hull as it slowly increases its depth?_____

Why? _____

b. Which measurement would be most relevant to a submarine hull when subjected to an underwater explosion?_____

Why? _____

15. In the lab, the Charpy v-notch test will be demonstrated at room temperature and at a lower temperature.

- In the box, sketch the Impact toughness against temperature curve for a regular steel. Make sure you label the axis correctly.

- On the sketch show where the material is behaving with brittle behavior and ductile behavior and indicate the transition temperature.

16. At what temperatures would it be desirable to use this material sketched above?

_____

Why? _____

Part 2: Lab Questions

Fatigue Testing

17. What is the purpose of fatigue testing? _____

_____

18. In the box below sketch the plot obtained from a fatigue test at a number of different stress levels for a regular steel and a regular aluminum. Ensure you label the axis correctly and show any significant points.

19. Using the information in this sketch, what advantage does steel have over aluminum as a structural material?_____

_____

Hardness

20. Hardness is defined as:

> *"..... a measure of a material's ability to resist indentation, abrasion and wear."*

How is the hardness of a material measured? _____

_____

How is this converted to find the strength of a material? _____

_____

Non-Destructive Testing

21. For the following non-destructive testing techniques, describe the type of material flaws and faults that they can find and one operational disadvantage they incur.

Radiographic Testing

Material Flaws_____

Disadvantage _____

Eddy Current Testing

Material Flaws_____

Disadvantage _____

Ultrasonic Testing

Material Flaws_____

Disadvantage _____

Magnetic Particle Testing

Material Flaws_____

Disadvantage _____

Visual/Dye Penetrant Testing

Material Flaws_____

Disadvantage _____